Jet Reconstruction in Heavy-ion Collisions at ALICE at the LHC

S-L Blyth[1,2], M.J. Horner, H. Gray, J.L. Klay, G. Odyniec, M. van Leeuwen for the ALICE-USA Collaboration
[1]*Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, California 94720*
[2]*Department of Physics, University of Cape Town, South Africa*

It is expected that heavy-ion collisions of Pb+Pb at the Large Hadron Collider (LHC), at $\sqrt{s_{NN}}$ = 5.5 TeV, will produce a phase of matter consisting of deconfined quarks and gluons called the quark-gluon plasma (QGP). Since hard probes, for example high-p_T jets, are formed early in the collisions and interact with the produced medium, they can be used to probe the medium properties. Jets are expected to lose energy via gluon radiation (jet-quenching) [1] before fragmenting into hadrons. This jet energy-loss will modify the jet fragmentation function defined as $D_{h/q} = dN_{ch}/dz$ where $z = p_L/E_{T\,jet}$ and p_L is the momentum of a jet particle parallel to the jet axis. Therefore, by measuring the jet fragmentation functions, information on the medium properties, such as initial gluon density, can be deduced.

At ALICE at the LHC, the predicted cross-section for jet production is significantly larger than at RHIC [2]. A cone-type jet-finding algorithm, based on the UA1 approach used in particle physics [3], has been adapted to be used in heavy-ion collisions. The algorithm is designed to use a combination of data from the ALICE tracking detectors and the electromagnetic calorimeter (EMCal).

The algorithm was optimised to reconstruct jets with energies $\geq$ 50 GeV in Pb+Pb collisions. Jets in Pb+Pb collisions at $\sqrt{s_{NN}}$ = 5.5 TeV were simulated using the Monte Carlo event generator PYTHIA [4] superimposed on HIJING [5] background events. The ALICE detector response was simulated using GEANT3 and a fast tracking simulation.

The optimisation to reconstruct accurately the jets' energies and directions, while minimising the number of reconstructed 'fake' jets, included a method of calculating and subtracting the background energy on an event-by-event basis. The fluctuations in the background energy required the use of a small cone radius of $R = 0.3$ (where $R = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$). The remaining two parameters, the seed energy E_{Seed}, around which the jet-finding process starts, and the minimum cone energy E_{MinJet} required to be considered a jet, were tuned to $E_{Seed} = 4.6$ GeV and $E_{MinJet} = 14.0$ GeV. The final value of the reconstructed jet energy includes corrections for losses from algorithm and detector effects. For a detailed description see [6]. The raw reconstructed and corrected jet energies for three samples of mono-energetic jets are shown in Table. I.

TABLE I: Input, reconstructed and corrected jet energies from 3 mono-energetic jet samples

E_{Input}	**50 GeV**	**75 GeV**	**100 GeV**
$\langle E_{Reco} \rangle$	36.0 GeV	52.5 GeV	69.4 GeV
$\langle E_{Corr} \rangle$	49.8 GeV	76.8 GeV	103.0 GeV

The resulting reconstructed jet energy resolutions for Pb+Pb and p+p events is shown in Fig. 1. The resolution is defined as σ/E_{Reco}. As jet energy increases, the Pb+Pb resolution approaches the p+p result.

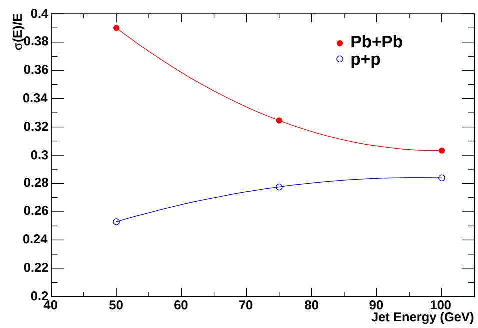

FIG. 1: Jet energy resolution as a function of jet energy for the Pb+Pb case (red) compared to the p+p case (blue).

The RMS of the reconstructed jet direction resolution is shown in Fig. 2. The values for the Pb+Pb case are very similar to the p+p case and improve with increasing jet energy.

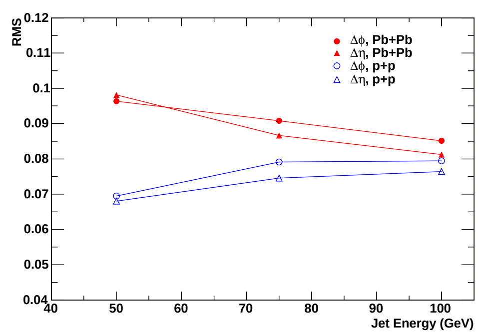

FIG. 2: RMS of reconstructed jet direction distributions for Pb+Pb case (red) and p+p case (blue) as a function of jet energy.

In conclusion, using the ALICE detector at the LHC, we have demonstrated that jets can be reconstructed, with good accuracy and resolution, for the first time in heavy-ion collisions using an adapted cone-type algorithm.

[1] X. N. Wang and M. Gyulassy, Phys. Rev. Lett. **68**, 1480 (1992).
[2] M. Gyulassy and I. Vitev, Quark Matter Conference (2002).
[3] W. Christie and K. Shestermanov, STAR Note 196 (1995).
[4] T. Sjostrand, Computer Physics Commun. **135**, 238 (2001).
[5] X. N. Wang and M. Gyulassy, Phys. Rev. D **44**, 3501 (1991).
[6] S.-L. Blyth, MSc. Thesis (2004).